Bernd Blume, bernd.blume@web.de
Klaus Morgenstern, klausjums@aol.com

Project: Energy use and climate – Conception of an project orientated learning method in 11th school year

Klaus Morgenstern, Bernd Blume

Scientific Experiments and research models on the subjekt of "Climate and Problems with Climate"

Planning

A complex subject as climate problems requires special basic knowledge in various scientific disciplines as well as in geography and history. The new systrem of secondary school education in Schleswig-Holstein allows to combine the named subjects and gives time to work together in projects. But before starting a project it is necessary to define which basic knowledge should be tought and at what stage.

Biology	Chemestry	Physics	Geography
Cytology and physiology: cells – base of life	chemical balance	Light, color and energy change	Climate zones and vegetation
photosythesis and cell breathing	principle of compulsion	Absoption, reflection and emission of radiation	
CO_2-metabolism and change into energy	CO_2(g), CO_2(aq)-the solubility in water (influence of temperatur)	Constitution nand role of solar cells; energy transformation. f. e. Wind energy in electric energy	
	the natural lime circulation; CO_2 binding and releasing		
	Protolyse reactions, acid –base theory of Brønsted; carbonic acid		

Method of working:

- to ask questions
- to formulize hypothesis

- to look for informations (from institutions, intitutes, libraries, internet and interviews)
- to prepare and carry out experiments,
- to put results together and evaluate them
- to illustrate the resultsof the research
- to communicate the results

Subjects of groop working:

1. Facts speaking for change in climate
2. effects of changes in climate
3. Solar eneregy – a chance to stabilize the climate?
4. Wind energy – a chance to stabilize the claimate?
5. Energy waste to the way to school.
6. Energy balance at school and saving opportunities
7. We are all involved in the necessity of saving energy

And others. Look for the interests of the sudents.

Scientific input: There will be experiments presented on ***four subject areas***.

a. Experiments to answer the Question: Is there proof of the greenhouse effect?
b. There is a natural caused content of carbon dioxide in the air, and therefore a natural greenhouse effect.
c. Humans strengthen the natural greenhouse effect.
d. possible consequences of the natural greenhouse effect.

The goal of the experiments is to aquire well-founded knowledge to the changing impact between human actions and climate conditions.
These experiments are limited to the representation and proof of qualitative connections (yes or no reponses). Quantitative (numerical) statements with the given possibilities are not practical, corresponding statements would not be serious.

Experiment 1: ***A transparent house "collects" warmth***
Experiment 2: ***Different colors absorb and emit light and warmth rays with varying strengths***
Experiment 3: ***CO_2 -gas absorbs heat rays more than normal "air": CO_2- gas is "thermally darker" than normal air***
Experiment 4: ***Absorpion of warm rays in CO_2 -gas leads to a rise in the temperature in the CO_2 -gas***
Experiment 5: ***A CO_2 -layer closer to the earth is wormed up more than higher layers of atmosphere***
Experiment 6: ***the automobil .... a climate problem!***
Experiment 7: ***Humans and animals also emit CO_2 -gas, therefore also contributing to the greenhouse effect***
Experiment 8: ***Plants influence the natural greenhouse effect***
Experiment 9: ***Ecosystems influence the natural greenhouse effect***
Experiment 10: ***Through the burning of fossile fuels (fields as well as forests) humans release additional CO_2 in the atmosphere!***
Experiment 11: Storms and temperature changes threaten the existing vegetation
Experiment 12: ***Water is a carbon dioxide buffer. The oceans act as a "carbon dioxide reducer" because they can absorb the gas from the air***
Experiment 13: ***Possible changes of climate in Europe. Cooling down!***

Experiment 1: *A transparent house "collects" warmth*

This experiment links the every day experience, that closed spaces (unheated) are basically heat catchers. The obvious experiences are the greenhouses and the unbearable hot car in the summer. This experiment should help shift these often unconcious experiences into concious perception.

Materials

A small greenhouse (glass or acrylic tanc with thin walls)
2 mercury thermometers, 1°-divisions (or more exact)
even, singlcolored bottom,
direct sun rays or diffused daylight as a light source.

Experimental Arrangement

The glasshouse will be built on a single coloured bottom. In the house, on the bottom, will be a thermometer. On the same colored bottom, next to the house will be a second thermometer. Direct sunlight will be better than diffused light as a light source. Mercury thermometers should be used, because the direct sunlight is reflectedd off of it, and only the air temperature is recorded.

Experimental Procedure and Measurement

Observe the temperature increase and the final temperatures of both thermometers.

Measurement results

The temperature in the greenhouse rises faster than outside of the house. The end temperature in the house is considerably higher (Delta T 8K) than outside of the house.

Special Characteristics

This experiment was conducted behind an insulated glass window during different weather conditions. It showed that during this weather, even considerable temperature differences exist (Delta T 2K).

Experiment 2: Different colors absorb and emit light and warmth rays with varying strengths

This experiment links - as a greenhouse experiment - more or less well-known everyday experiences.

Materials

3 different colored sheets of paper - (in our experiment: black, green and white),
3 thermometers of the same kind,
illumination: diffused day light or direct sunlight.

Experimental Arrangement

Three thermometers should be laid on three sheets of paper.

Measurement Results

Due to the different colored bases, the thermometers shows different results. Black shows the highest, and white shows the lowest temperature.

Special Characteristics

The thermometers must have the same color in order to avoid absorption mistakes. Caution: This experiment can (totally unexpectedly) fail. Not every optical white is a thermal white. This means it can absorb in the infared sphere.

Experiment 3: CO_2 -gas absorbs heat rays more than normal "air": CO_2-gas is "thermally darker" than normal air

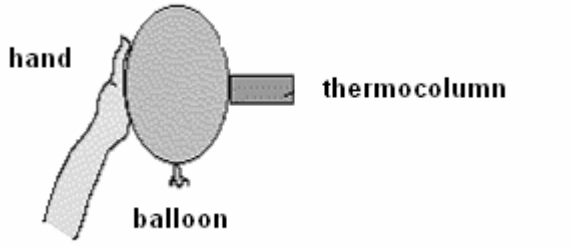
Material

CO_2-gas, 2 same color balloons (condoms work well),

thermocolumn, measuring amplifier.

Experimental Arrangement and Procedure

An air-filled balloon will be pushed onto the thermocolumn. The hand is at the same time the heating element and the thermocolumn must be at opposite sides of the balloon.



Afterwards a balloon filled with CO_2 will be placed in the same way. The measurement of the connected measuring amplifier should be observed.

Special Characteristics

Understandably this experimentonly shows strong absorption. It is not proof, that there is a simultaneous warming of gases. In case this seems illogical to the reader, he/she should just remember the warmth that makes ice cream melt, without increasing the temperature of the ice cream. Basically it is possible, that the warmth absorption of other physical and chemical reaction produces an increase of temperature.

Experiment 4: Absorpion of warm rays in CO_2 -gas leads to a rise in the temperature in the CO_2 -gas

Materials

quarz heater

2 Biochorias (acrylic tancs, see Tips and Tricks at the end), Styrofoam dividing layer, 2 Thermometers (1° division or more exact), heater (here , red glowing), CO_2.gas

1. Experiment

Both areas are filled with air and are warmed by the heater.

2. Experiment

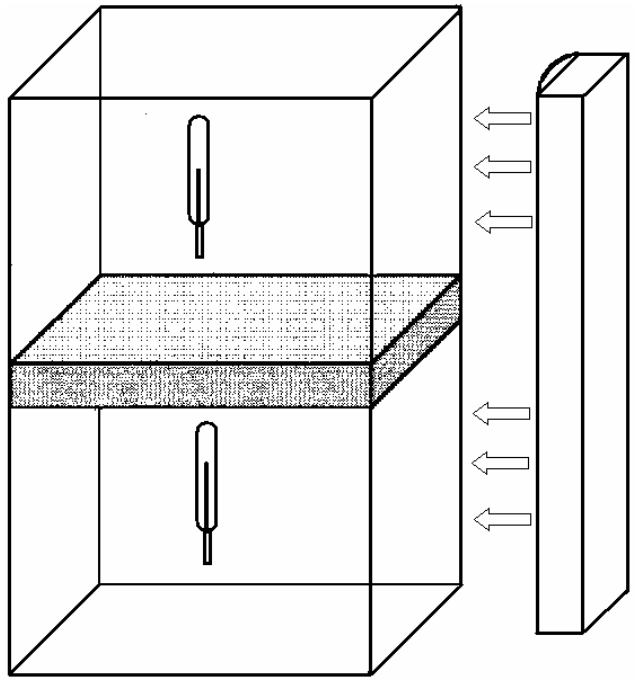
The lower aria is filled with CO_2. Both areas are equally warmed.

Instead of Biochorias other "containers" can be used. The wall of the container should be thin and able to be vertically warmed. The ray absorption of the wall closest to the heater cannot be neglected. It should be understood that the container cannot be too small and must be able to be heated from the side. Our Biochorion had the measurements of L x B x H = 40x40x40 cm^3.

Measurement results

The first experiment (only air) showed an equal warming of both areas.

The 2^{nd} experiment (with CO_2 in the bottom) showed a 1,5°C higher temperature in the CO_2 area.



Information

This experiment shows, that the absorption of close infrared rays leads to a rise in the temperature. The styrofoam layer thermally divides the two gas areas, which creates 2 different isolated gas levels. Without this division there would be a stronger heating of the lower layer (CO_2) and the heat would diffuse causing the "hot plat effect". This means that the CO_2 area would immediatly begin to heat the above area.

Experiment 5: *A CO_2 -layer closer to the earth is wormed up more than higher layers of atmosphere*

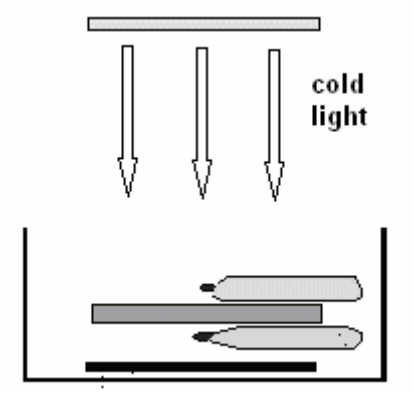
This experiment is concerned with the key question of the entire climate problem, namely if all of the climate factors are in the area closest to the earth. It is interesting because it can be done with amazingly simple materials and with a relatively simple explanation, and yet is very convincing.

Materials

Tub (for avoidence of draft), black cardboard (to simulate earth's surface), acrylic glass ˜ 5 mm (simulates CO_2-holding air), 2 thermometers (1/10° divisions), fluorescent (white) lamp as cold light source.

Experimental Arrangement

In the bottom of the tube, lay the black cardboared. Lay a thermometer on the cardboard. The hollow container (mercury container of the thermometer) should not touch the cardboard. On the thermometer place the layer of acrylic glass. On top of the acrylic glass place a second thermometer.



Experimental Procedure
The above explained construction will be horizontally lighted from above with the added light rays (fluorescent light at an adequate distance). Observe the temperature increases and the final temperatures.
Measurement Results
A resasonable time of observation is 20 to 30 minutes. The bottom thermometer shows a .2 to .4 K higher temperature

Analogical Reflections and experiment explanation
Acrylic lets light through (as one can see). Warm rays are only let through in small amounts. You can easyly test this, through putting acrylic between a heater (for example elektric iron) and the cheek. Acrylic has similar properties as CO_2 gas and we can use it in place of CO_2 in this experiment.
The atmosphere (the acrylic) lets through sun light (the visible part) unhindered. Light reaches the earth earth (black cardboard). A part is absorbed and warms the earth's surface. The warmed earth surface sekundarily acts as a warmth source. This warmth would be distributed througout the earth's atmosphere, if it weren't for the CO_2 content of the air. The CO_2 layer absorbes the heat and heats itself . What does a warm body (even when it is made of gas) do? It sends warmth out in all directions. Above to the atmosphere and below into the earth's surface, and it becomes even warmer.
Under the CO_2 layer the earth sends heat upward (back into the CO_2 layer), and then the CO_2 layer warms downwards (into the earth). Above, the rays are only sent upward by the CO_2 layer, (because the CO_2 layer absorbs the warmth of the earth and doesn't let it through).
It can be seen, that it becomes warmer *under* the CO_2 layer (in the experiment under the acrylic plate), than above this plate.
This example should provoke amazement and thought, because it contradicts our everyday experiences, that an area become hotter, when we warm it directly - it is, but with *warmth* rays. *This* is the difference.

The following experiments take for granted the knowledge of the greehouse effect by CO_2 gas. The thesis of these experiments is:
The ecosystems produce a natural carbondioxide content of the air. Man increases the CO_2 content of the air and strengthens the greenhouse effekt.

Experiment 6: the motor car .... a climate problem!

Materials
Motor car, 4 (one big 50L, three small 20L) garbage bags, gas detector pump accuro from Dräger, Dräger Short Term Detector Tubes for CO (measuring range 0,3-7Vol.%) and CO_2 (measuring range 1-20Vol%) clock/stopwatch, folding rule, piece of chalk, piece of string or alternative: suction pump

Experimental Procedure
The teacher and two students drive 10 m in a car. Afterwards the students push the car over the same distance. The time of pushing has to be stopped. The garbage bags will collect the air exhaled by the students and the emission of the car. The volume of the closed garbage bags can be calculated after having formed cylinders of them and after having measured their radius and height or measured with a suction pump.
5 minutes after the experiment the two standing students exhale the time of pushing in two other bags.
The CO and CO_2 content will be determined at the end with detector tubes.
Notice: You must be sure that the car is already moving when the experiments begin. (One detector tube - you have to divide by two the measured value - is enough for the two students). The temperature of the car emissions must be lower than 40°C.

Results and Calculations (example includeded)
1. Calculation of the volume of the exhaled air and car emissions:
$V = 3.1416\ r^2h$
Results for 10 m distance:
Car: 40L emission with 14% CO_2 and more than 3000ppm CO.
Students: about 20L exhaled air with 3% CO_2 (without CO) in 8sec
Standing Students*: about 17L exhaled air with 2,5% CO_2 (without CO) in 8sec
*Measurement 5 minutes after the other experiments.

2. Calculation of the mass of CO_2
To calculate the approximate mass of CO_2, m(CO_2) in the bags you may use the Ideal Gas Equation. In this case you need additional information about pressure and temperature and that V_o/mol(CO_2) = 22,26 L. In the garbage bags the temperature and pressures are higher than 0°C and 100 kPa, but in an approximate calculation you can neglect this piece of information and calculate with V/mol(CO_2) = 22 L
Calculation: n(CO_2) = overall volume x content of CO_2 /(22L/mol)
m(CO_2) = n(CO_2) x M(CO_2) M(CO_2) means molar mass of (CO_2)
n(CO_2, car emission) = 40 x 0.14/22 = 0.255mol, m(CO_2) = 0.255 x 44 = **11.2 g**
n(CO_2, students) = 20 x 0.03/22 = 0.0273mol,
n(CO_2, standing students) = 17 x 0.025/22 = 0.0193mol
n(CO_2, students) - n(CO_2, standing students) = 0,00798mol
m(CO_2) = 0.00382 x 44 = **0.168g**
that means that the 11.2 : 0.168 = **67** fold of CO_2 is set free in the air during driving with the car compared with pushing the car. In addition the students produce no carbon monoxide.

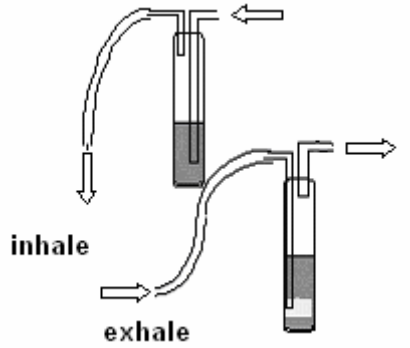
Valuation
One should notice, that this experiment does not claim exactness of results. It shows that one should not use the motor cars so much.
Whoever loves a stabile climate pushes his car!

There is a natural causal CO_2 content in the air, and therefore a natural greenhouse effect.

Experiment 7: *Humans and animals also emit CO_2-gas, therefore also contributing to the greenhouse effect*

Material
2 (gas) washbottles with small hoses and glasstubes, 2 stands with clamps, fresh calcium hydroxide solution, ethanol.

Experimental Procedure
The washbottles should be connected to the hoses and the glass tubes, then connected to the retord stand. The glass tubes should be cleaned with ethanol. After that the wash bottles will be filled 3 cm high with calcium hydroxide solution.



Experimental Procedure
Careful! Corrosive Solution. A student inhales 2 times through one wash bottle and exhales 2 times through the other one.
Observation
In the first wash bottle you can observe a white, milky precipitation, in the second only a white opaque.
Results and valuation
A calcium hydroxide solution is a reagency to CO_2 because it reacts with CO_2 to create white calcium carbonate.
We exhale more CO_2 than we inhale.

Experiment 8: *Plants influence the natural greenhouse effect*
2 ivy plants (they have a low compensation point), 1 dark and one clear plastic bags, ties, 1 fluorescant lamp, 1 "Dräger" gas detector with CO_2 test tubes or three beakers with fresh calcium hydroxide solution, three glas tubes with tops and 1 bag for a blind test.
Experimental Procedure
Put one ivy plant in the dark plastic bag (1) and tie it, put the other in the clear bag (2). The clear bag must be exposed to light. After at least one hour the CO_2 contents of the air in the bags is measured. (If you have no gas detector you can sqeeze the air into a calcium hydroxide solution. Fill another bag with air and do the same as a blind test).
Measured Values (Results)
CO_2 content
dark bag (1): 0,1%,
clear bag (2): 0,01%
normal air: 0,03%
Valuation

Plants photosynthesize and respire. During Photosythesis they take in CO_2 and change it by reduction to glucose.
light
$6CO_2 + 12H_2O$ ® $C_6H_{12}O_6 + 6H_2O + 6O_2$
Altogether plants reduce the CO_2 content of the air, but when there is lack of light the plants give out CO_2 by respiration.
$C_6H_{12}O_6 + 6O_2$ ® $6CO_2 + 6H_2O$
The careful reader of the measured values will notice, that the light period must 3.5 times so long as the dark period, which does not correspond to the experiment. The reason is that CO_2 is solving in condensation water in the plastic bag, so the results are only qualitative.

Experiment 9: *Ecosystems influence the natural greenhouse effect*

Material
2 beakers (500mL), 1 dark and 1 clear plastic bag, 1 fluorescent lamp, 1or 2 pH meters, pond water with living plankton algae and submerse macrophytes.
Experimental Procedure
About 1 L of pond water with plancton along with a beaker will be put in a dark plastic bag (1). The same is done with the clear bag (2). Then the clear bag is put under light for about one hour. Then the pH-values of the water in both beakers are measured. Notice: Continuous measurements are also possible.
Measured Values (Results)
The pH in (1, dark bag) for example is 6,91, in (2, clear bag) 6.98.
Valuation
The organisms in the dark bag set free CO_2 through respiration. The pH falls because CO_2 reacts with water by forming cabonic acid. In the clear bag the phytoplancton, other algae and submerse makrophytes takes in CO_2 from the water. Therefore the pH value increases, even in the alkaline area. Under these conditions, CO_2 is much more easily taken out of the air. Aquatic systems influence the "greenhouse earth", the CO_2 balance can be positive or negative.

Experiment 10: *Through the burning of fossile fuels (fields as well as forests) humans release additional CO_2 in the atmosphere! Text demonstriert den*

Materials
1 glass funnel, two stands with clamps, 3 washbottles, 1 water pump (suction), 2 hose connections, 2 porcelain basins, 1 clock, gasoline, pieces of wood, calcium hydroxide solution.
Experimental Arrangement
The glass funnel is placed upside-down, and connected to the stand. The porcelain basins placed underneath the funnel. The funnel is connected by a hose to the wash bottle which is on another stand. The wash bottle is connected to the water pump.
Experimental Procedure
The gasoline as well as the wood will be burnt in the porcelain basin at seperate times. The remaining gases will be sucked through the funnel and into the washbottles. Measure the time of experiment (end when there is a precipitation). Blind test without burning!
Observation
There is a noticable faster build up of milky precipitation than in blind test without burning.

Results and Valuation
By burning fossil fuels as well as wood, a great amount of CO_2 is set free into the atmosphere. This increases the greenhouse effect.

Experiment 11: *Storms and temperature changes threaten the existing vegetation*

Material
Stand with clamps, hair dryer, 2 blocks of cress plants about 3 cm wide.
Experimental Procedure
One block os cress plants is blown by a hair dryer.
Observation
After a short time the plants will be lying irreversibly flat on the ground.
Valuation
This experiment shows that cress can't exist in warm, dry air. The plants can't survive drastic environomental changes. Large climate changes are predicted for the future. This experiment shows that climate changes can possibly change or destroy vegetation.

Experiment 12: *Water is a carbon dioxide buffer. The oceans act as a "carbon dioxide reducer" because they can absorb the gas from the air*

Water is a CO_2 buffer. The oceans reduce the CO_2 content of the air; because they can absorb the gas from the air.
Materials
250 mL Erlenmeyer flask, pH-meter, CO2 bottle, (sea)water.
Experimental Procedure
H_2O with a known pH is put in the flask. CO_2 is placed above the H_2O. Then the pH of the water is continuously measured.
Observation
The pH of the H_2O is continuously measured.
Results and Valuation
CO_2 is solved in water. The thesis "Oceans reduce CO_2 contents of the air" is correct. The increase of CO_2 in the atmosphere shows thast this effect is not sufficient, only slows the increase.
Additional Experiment
Materials
1 liter plastic bottle, CO_2 bottle, tap water.
Experimental Procedure
The plastic bottle is filled about ¼ (one fourth) with water, and topped with CO_2. Close the bottle and shake it.
Observation
The plastic bottle curves in.
Results and Valuation
Through shaking the surface of the water is increased. CO_2 is absorbed more quickly. The gas volume decreases.

Experiment 13: *Possible changes of climate in Europe. Cooling down!*

Thesis: There is a threat of change of climate (cooling) because a weakening of the Gulf Stream.
Materials

2 small aquariums, 1 glass rod, 1 beaker, 1 hair dryer, ink, 1 peace of paper, 0,5 kg Salt.

Experimental Procedure

An aquarium is filled with salt watzer. A piece of paper is laid on top of the water. Afterwards a layer of colored salt water is gently poured on the top of the pater. The paper is removed. Gently, then use the hair dryer to blow across the water Horizontally.

Observation

The layers disappear, the water mixes.

Experimental Procedure 2

The same as above but with salt water as bottom layer, and fresh water as the top layer.

Observation

The fresh water hardly does not mix whith the salt water. There is no complete circulation.

Results and Valuation

Fresh water has a lower density than salt water, and "swims" on top of it. It is possible that melting ice from the poles produces a layer of fresh water on top of the salt water. This influences the Gulf Stream by decreasing its density. The Gulf Stream water des not sink and does not return to the caribian. The consequence is that the Gulf Stream loses influence to the west European climate. The possible result could be a general lowering of temperature in West Europe.

Tips and Tricks

The problems of materials

CO_2 gas: gas bottle, CO_2 cartridges. For small amounts it's sufficent th shake a bottle of soda water.

Biochorien: Variable boxes of acrylic glass with removable top and bottom, stackable, experiment 4 shows two floors. Construction: Dr. Christion Qtzen - University of Kiel. Department of Education - Chemestry. Order to Urhammer in D-24105 Kiel, Brunswiker Str. 40, Tel 0049 431 561033.

Alternative: You can use aquariums with thin walls or a wooden frame with plastic wrap.

Thermometers: Some experiments require mercury thermometers. Alkohol thermometers are not recommended because of absorption of rays. Be careful because mercury is poisonous.

Quarz heater: Heaters which you usually find in bathrooms. It's important that it is straight not crooced, and that the heat element is in an electrical isolater quartz tube.

Gas detector: Product information: http://www.buydraegertubes.com/ca-cy.aspx
http://www.draeger.com/ST/internet/US/en/Products/Detection/Drager-Tubes/Pumps/accuro/pd_accuro.jsp
http://www.afcintl.com/gasdet/draeger/accuro.htm